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FORM PTO 1390 (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER SONYJP-105
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 CFR 1.5) <div style="font-size: 1.5em; font-weight: bold; margin-top: 10px;">09/674887</div>
INTERNATIONAL APPLICATION NO. PCT/JP00/01384	INTERNATIONAL FILING DATES 8 MARCH 2000	PRIORITY DATE CLAIMED 8 MARCH 1999
TITLE OF INVENTION DIGITAL SIGNAL PROCESSING APPARATUS AND METHOD AND PROVIDING MEDIUM		
APPLICANT(S) FOR DO/EO/US Ikuo TSUKAGOSHI et al.		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371 (f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371 (b) and PCT Articles 22 and 39(1). 4. <input type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c)(2)) <ol style="list-style-type: none"> a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371 (c)(2)), including Request. 7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) <ol style="list-style-type: none"> a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)). 9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). (Unexecuted) 10. <input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)). 		
Items 11. to 16. below concern document(s) or information included:		
<ol style="list-style-type: none"> 11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98, with PTO-1449, 6 references 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 & 3.31 is included. 13. <input type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 14. <input type="checkbox"/> A substitute specification. 15. <input type="checkbox"/> A change of power of attorney and/or address letter. 16. <input checked="" type="checkbox"/> Other items or information: 		
A Translation of the PCT Request Eleven (11) Sheets of Formal Drawings		

Form PTO-1390 (Rev 10-96)

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EXPRESS MAIL LABEL NO. EL 408437795US
 DATE: November 7, 2000

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U.S. APPLICATION NO. (if known, see 37 CFR 1.5) <div style="font-size: 1.5em; font-weight: bold;">09/674887</div>	INTERNATIONAL APPLICATION NO. PCT/JP00/01384	ATTORNEY'S DOCKET NUMBER SONYJP-105
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17. <input checked="" type="checkbox"/> The following fees are submitted: <div style="margin-left: 20px;"> BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) – (5)): <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00 <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 </div>	CALCULATIONS PTO USE ONLY																																												
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<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 25%;">CLAIMS</th> <th style="width: 25%;">NUMBER FILED</th> <th style="width: 25%;">NUMBER EXTRA</th> <th style="width: 25%;">RATE</th> </tr> <tr> <td>Total claims</td> <td>7 - 20 =</td> <td>0</td> <td>x \$18.00</td> </tr> <tr> <td>Independent claims</td> <td>6 - 3 =</td> <td>3</td> <td>x \$80.00</td> </tr> <tr> <td colspan="3">MULTIPLE DEPENDENT CLAIM(s) (if applicable)</td> <td>+ \$270.00</td> </tr> <tr> <td colspan="3">TOTAL OF ABOVE CALCULATIONS =</td> <td>1,100.00</td> </tr> <tr> <td colspan="4">Reduction of ½ for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).</td> </tr> <tr> <td colspan="3">SUBTOTAL =</td> <td>1,100.00</td> </tr> <tr> <td colspan="3">Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).</td> <td>+</td> </tr> <tr> <td colspan="3">TOTAL NATIONAL FEE =</td> <td>1,100.00</td> </tr> <tr> <td colspan="3">Fee for recording the enclosed assignment (37 CFR 1.21 (h)). Assignment must be accompanied by appropriate cover sheet (37 CFR 3.28, 3.31) (\$40.00 per property).</td> <td>+</td> </tr> <tr> <td colspan="3">TOTAL FEES ENCLOSED =</td> <td>1,100.00</td> </tr> </table>	CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	Total claims	7 - 20 =	0	x \$18.00	Independent claims	6 - 3 =	3	x \$80.00	MULTIPLE DEPENDENT CLAIM(s) (if applicable)			+ \$270.00	TOTAL OF ABOVE CALCULATIONS =			1,100.00	Reduction of ½ for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).				SUBTOTAL =			1,100.00	Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	TOTAL NATIONAL FEE =			1,100.00	Fee for recording the enclosed assignment (37 CFR 1.21 (h)). Assignment must be accompanied by appropriate cover sheet (37 CFR 3.28, 3.31) (\$40.00 per property).			+	TOTAL FEES ENCLOSED =			1,100.00	
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a. ☐ A check in the amount of _____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 12-1095 in the amount of \$1,100.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

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NOTE: Where an appropriate time limit under 37 CFR 1.494 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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 Registration Number

09/674887 48874960

VERIFICATION OF A TRANSLATION

I, the below named translator, hereby declare that:
My name and post office address are as stated
below;

That I am knowledgeable in the English language and
in the language in which the below identified
international application was filed, and that I believe
the English translation of the international application
No. PCT/JP00/01384 is a true and complete translation of
the above identified international application as filed.

I hereby declare that all statements made herein
of my own knowledge are true and that all statements made
on information and belief are believed to be true;
and further that these statements were made with the
knowledge that willful false statements and the like so
made are punishable by fine or imprisonment, or both,
under Section 1001 of Title 18 of the United States Code
and that such willful false statements may jeopardize the
validity of the application or any patent issued thereon.

Date October 31 , 2000

Full name of the translator Kunihiko KANO

Signature of the translator *Kunihiko Kano*

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DESCRIPTION

Digital signal processing apparatus and
method and providing medium

Technical Field

5 The invention relates to digital signal
processing apparatus and method and providing medium.
More particularly, the invention relates to digital
signal processing apparatus and method for encoding or
decoding video data and audio data by a software
process and relates to a providing medium.

Background Art

10 In recent years, a system for transmitting
digital video data and digital audio data of a TV
program through a satellite has been being spread. In
15 such a system, to compress a data amount, the digital
video data and digital audio data are encoded by, for
example, an MPEG (Moving Picture Experts Group) system
and transmitted.

20 In an encoding apparatus by a software
process, an encoding is performed synchronously with an
input period of video data. The input period has been
defined by various standards. For example, in the NTSC
(National Television System Committee) system, it is
set to 33.36 msec. The maximum processing time
25 (encoding time) allocated to one image is restricted by
the input period of the video data which has been
determined by such a standard. In other words, the

inputted video data has to be encoded and the process
has to be finished within the input period. The video
data encoded in this manner is recorded to a
predetermined recording medium or the like or
transmitted through a satellite.

A receiving apparatus for receiving digital
data transmitted through the satellite decodes received
data by the MPEG system. In case of decoding the
digital video data by a software process, it is
necessary to successively execute a plurality of
processes which are necessary for decoding. To output
in a real-time manner, it is necessary to complete all
of the processes necessary for decoding within a time
which is matched with a period that is required for
output. For example, in case of the NTSC system, since
a frame rate is equal to 30 frames/sec, one period is
equal to 33.36 msec. It is, therefore, necessary to
decode the digital video data of one frame within 33.36
msec.

In dependence on a situation of a stream
which is inputted or a situation of a video image which
is decoded, a time necessary for executing those
processes fluctuates. For example, in case of a video
image of the MPEG system, a time necessary for a
decoding process of a variable length code changes
depending on a bit rate of a bit stream. A processing
time of a motion compensation also changes depending on

a kind of picture coding type such as I picture, B picture, or P picture or depending on a difference of motion compensation precision such as half pel or full pel. Further, it also takes time to perform a process such as decoding or demultiplexing of the digital audio data as well as the video image. Further, a time which is consumed by the OS for managing the whole processes also fluctuates.

Therefore, in case of decoding by the software process by using a personal computer, when the decoding process cannot be performed within an output period, the process of a part of data is skipped and an output is decimated, thereby maintaining real-time performance.

As mentioned above, according to the conventional encoding apparatus, since the encoding is performed synchronously with the input period of the video data, the encoding has to be completed at the maximum precision within the input period for each image. The precision upon encoding depends on a similarity between the image before encoding and the image obtained by decoding the encoded image. The precision also depends on the processing time for encoding, encoding method, or the like.

In the case where the encoding process is changed on the time base (for example, MPEG (Moving Picture Experts Group) 2) or in the case where each

image has to be encoded at the closest precision as possible (to prevent a situation such that when the precision of the encoding differs on the time base, the decoded image flickers and becomes hard to be seen), an
5 encoding apparatus has to be designed by setting it so that there is an enough time for the encoding process in order to raise the encoding precision.

The encoding apparatus by the software process has to perform a control of an input, an output, and the like of the video data in addition to the encoding process, and those processes have to be simultaneously performed by a built-in processor. There is, consequently, a problem such that it is difficult to calculate the longest processing time which is allocated to the encoding process due to a relation with the processes other than the encoding process. Thus, there is also a problem such that a
10 vain time during which the processor executes no process is caused. As mentioned above, in case of
15 allowing one processor to perform a plurality of processes, there is a problem such that the processor needs to have a high processing ability and the costs rise.

The invention is made in consideration of
25 such a situation and it is an object of the invention to enable encoding at high precision to be performed even by a processor of a low processing ability by

allowing an encoding process of one image to be executed while preferentially executing other processes.

For example, in a dedicated receiving apparatus for receiving a satellite broadcasting, even in case of decoding a reception signal by a software process, the process for decimating an output by skipping a process of a part of data in order to maintain real-time performance should not be permitted in consideration of the fact that such an apparatus is a dedicated apparatus for decoding a digital video signal which is inherently transmitted through a satellite.

In order to enable the decoding to be completed in a short time by the software process, therefore, there are problems such that a processor having a very high processing ability is necessary and the costs are high.

The invention is made in consideration of such a situation and intends to enable a decoding process to be performed at low costs by a software process by using a processor having an ordinary processing ability.

Disclosure of Invention

According to claim 1, there is provided a digital signal processing apparatus comprising: input means for inputting an encoded digital signal; decoding

means constructed by software for decoding the digital signal inputted by the input means; first storing means for storing the digital signal decoded by the decoding means by an amount corresponding to a plurality of access units; and managing means for managing an outputting order of the digital signal of the access units stored in the first storing means by an FIFO format.

According to claim 3, there is provided a digital signal processing method comprising: an input step of inputting an encoded digital signal; a decoding step of decoding the digital signal inputted by a process in the input step by software; a first storing step of storing the digital signal decoded by a process in the decoding step by an amount corresponding to a plurality of access units; and a managing step of managing an outputting order of the digital signal of the access units stored by a process in the first storing step by an FIFO format.

According to claim 4, there is provided a providing medium for providing a computer-readable program for allowing a digital signal processing apparatus to execute processes, wherein the processes comprise: an input step of inputting an encoded digital signal; a decoding step of decoding the digital signal inputted by a process in the input step by software; a first storing step of storing the digital signal

decoded by a process in the decoding step by an amount
corresponding to a plurality of access units; and a
managing step of managing an outputting order of the
digital signal of the access units stored by a process
5 in the first storing step by an FIFO format.

According to claim 5, there is provided a
digital signal processing apparatus comprising: input
means for inputting video data; first storing means for
storing the video data inputted by the input means;
10 predicting means for predicting a data amount at the
time when the video data stored in the first storing
means is encoded; encoding means for encoding the video
data stored by the first storing means; and second
storing means for storing the video data encoded by the
15 encoding means, wherein the encoding by the encoding
means is executed if it is determined that the data of
the amount predicted by the predicting means can be
stored in the second storing means, and the encoding is
interrupted while the video data is being inputted by
20 the input means and is being processed.

According to claim 6, there is provided a
digital signal processing method comprising: an input
step of inputting video data; a first storing step of
storing the video data inputted by the input step; a
25 predicting step of predicting a data amount at the time
when the video data stored in the first storing step is
encoded; an encoding step of encoding the video data

stored by the first storing step; and a second storing step of storing the video data encoded by the encoding step, wherein the encoding in the encoding step is executed in the case where the data of the amount predicted by the predicting step can be stored by a process in the second storing step, and the encoding is interrupted while the video data is being inputted by the input step and being processed.

According to claim 7, there is provided a program for a medium, wherein the program comprises: an input step of inputting video data; a first storing step of storing the video data inputted by the input step; a predicting step of predicting a data amount at the time when the video data stored in the first storing step is encoded; an encoding step of encoding the video data stored by the first storing step; and a second storing step of storing the video data encoded by the encoding step, and the encoding in the encoding step is executed if it is determined that the data of the amount predicted by the predicting step can be stored by a process in the second storing step, and the encoding is interrupted while the video data is being inputted by the input step and being processed.

In the digital signal processing apparatus according to claim 1, the digital signal processing method according to claim 3, and the providing medium according to claim 4, the stored outputting order of

the digital signal of the access units is managed by the FIFO format.

In the digital signal processing apparatus according to claim 5, the digital signal processing method according to claim 6, and the medium according to claim 7, the data amount at the time when the inputted video data is encoded is predicted, the video data is encoded, the encoded video data is stored, the encoding is performed when it is determined that the data of the predicted amount can be stored, and the encoding is interrupted while the video data is being inputted and processed.

Brief Description of Drawings

Fig. 1 is a block diagram showing a constructional example of a digital signal processing apparatus (decoder) to which the invention is applied.

Fig. 2 is a diagram showing a construction of a video frame buffer 3 in Fig. 1.

Fig. 3 is a diagram showing a construction of an output FIFO 4 in Fig. 1.

Fig. 4 is a timing chart for explaining the operation of the apparatus of Fig. 1.

Fig. 5 is a flowchart for explaining the operation of a process 1 in Fig. 4.

Fig. 6 is a flowchart for explaining the operation of a process 3 in Fig. 4.

Fig. 7 is a block diagram showing a

constructional example of a digital signal processing apparatus (encoder) to which the invention is applied.

Fig. 8 is a diagram for explaining a video frame buffer 13.

5 Fig. 9 is a flowchart for explaining a writing process of video data into the video frame buffer 13.

Fig. 10 is a flowchart for explaining an encoding.

10 Fig. 11 is a diagram for explaining processes within a range from an input of the video data to an output.

Fig. 12 is a diagram showing a sequel to Fig. 11.

15 Fig. 13 is a diagram for explaining media.
Best Mode for Carrying Out the Invention

A digital signal processing apparatus for decoding by a software process will be first described. Fig. 1 shows a constructional example of a digital
20 signal processing apparatus to which the invention is applied. A decoding program for performing a decoding process of an inputted stream, a processing program for controlling each section, and the like have been stored in a program memory 2. A CPU 1 properly reads out the
25 program stored in the program memory 2 through a bus 7 and executes it. A video frame buffer 3 is a storing apparatus for temporarily storing decoded video data

and has a capacity to hold video data of a plurality of frames.

An output FIFO (First In First Out) 4 stores management IDs of buffers 1 to N in which images of frames to be outputted have been stored in the outputting order. A stream input interface (I/F) 5 executes an interface process for inputting a transport stream which is transmitted through a satellite or the like and has been encoded by, for example, the MPEG system. A display controller 6 executes a process for outputting the decoded video data to a display (not shown) and displaying it.

As shown in Fig. 2, the video frame buffer 3 has the buffers 1 to N as areas for storing the video data of N frames. It is not always necessary to define those buffers into continuous address areas. Each buffer is used in order of the allocation for a decoding output, the holding of a decoding result, and the output of the data. The buffer in which the output has been finished is used again as a buffer for decoding output. Further, all of the buffers are equivalently used and are not used for an application in which a specific buffer is limited.

The output FIFO 4 can be also formed in the video frame buffer 3.

Fig. 3 shows a principled construction of the output FIFO 4. The output FIFO 4 manages the order of

the buffers for outputting the decoding result and a delay that is caused before the output. Management IDs or pointers of the buffers 1 to N of the video frame buffer 3 shown in Fig. 2 are inputted and stored in the output FIFO 4 in the outputting order.

The operation of the apparatus shown in Fig. 1 will now be described with reference to a timing chart of Fig. 4. In Fig. 4, each of time t1 to time t4 indicates a timing for outputting the decoded video data. That is, each interval between time t1 and time t4 is set to a period (33.36 msec) of one frame. The CPU 1 executes a process 1 at the timing of time t1 in accordance with a program read out from the program memory 2. When the process of the process 1 is finished, the CPU 1 subsequently executes a process 2. When the process of the process 2 is completed, the CPU 1 subsequently executes a process 3. In this manner, regarding the priorities of the processes, the process 1 is set to the highest priority, the process 2 is set to the second highest priority, and the process 3 is set to the lowest priority, respectively.

The process 1 will now be described with reference to a flowchart of Fig. 5. In step S11, the CPU 1 obtains the ID of the buffer to which the data is outputted next from the output FIFO 4. In step S12, the CPU 1 reads out video data corresponding to the ID obtained in step S11 from the video frame buffer 3 and

outputs it to the display controller 6 via the bus 7.
The display controller 6 outputs the inputted data to
the display (not shown) and allows it to be displayed.

For example, "A" has been held as a
5 management ID at the head in the output FIFO 4 at time
t1 shown in Fig. 4. In step S11, the CPU 1 reads out
"A" as a management ID from the output FIFO 4, reads
out the video data of the buffer corresponding to the
management ID "A" among the buffers 1 to N in the video
10 frame buffer 3, and outputs it.

The CPU 1 subsequently executes the process
2. For example, the process 2 is a decoding process of
audio data. The processed audio data is generated from
speakers (not shown) synchronously with a predetermined
15 timing signal which is outputted from the display
controller 6.

When the process 2 is finished, the CPU 1
subsequently executes the process 3. The details of
the process 3 will now be described with reference to a
20 flowchart of Fig. 6.

First, in step S21, the CPU 1 executes an
allocating process of the buffer for the next decoding
output. That is, the empty buffer (which has already
been read out) among the buffers 1 to N of the video
25 frame buffer 3 shown in Fig. 2 is allocated as a buffer
for storing the decoded video data. In next step S22,
the CPU 1 decodes the video data of one frame inputted

from the stream input interface 5 by the decoding
program read out from the program memory 2 by the MPEG
system. The decoded data is stored in the buffer
allocated in step S21. Further, in step S23, the CPU 1
5 registers the ID of the buffer to be outputted (read
out) next into the output FIFO 4.

At a timing between time t1 and time t2 in
Fig. 4, the decoding process of the frame in which the
management ID is set to D has been performed by the
process 3. Therefore, the CPU 1 registers D as a
10 management ID into the output FIFO 4. In the example
of Fig. 4, the process 3 can be completed in a period
of time from time t1 to time t2.

On the other hand, for a period of time from
time t2 to time t3, after video data of a frame in
which a management ID is set to B was outputted as a
process 1, a process of the audio data or the like is
15 executed as a process 2 and, after that, the process 3
is started. However, the process 3 cannot be completed
for a period of time until time t4.

In such a case, hitherto, the image of the
frame which has been outputted at just previous time t2
and whose management ID is set to B is outputted again
at time t3. However, in the invention, after the
25 process of the process 3 was temporarily interrupted at
time t3, an image of the frame which has been stored in
the output FIFO 4 and whose management ID is set to C

is outputted as a process 1. Subsequently, after the process 2 was further executed, when it is finished, the process which was once interrupted is restarted as a process 3. After that, subsequently, a process of the video data of the next frame is executed. In the example of Fig. 4, the video data of two frames whose management IDs are set to E and F can be processed for a period of time from time t3 to time t4, and E and F as management IDs of those frames are stored in the output FIFO 4.

As mentioned above, by enabling the buffers 1 to N to be managed by the output FIFO 4, even in the case where the execution time of the process 3 temporarily exceeds the output period or in the case where the execution timings of the process 1 and process 3 become asynchronous due to the reduction and extension of the execution time of each process, the buffer to which the data is outputted at a predetermined period can be always assured in the process 1.

As mentioned above, the processing ability of the software that is required for the CPU 1 does not need to be made to correspond to the case where the processing time that is required for decoding of one frame becomes the longest time. It is sufficient to make it to correspond to the average processing time that is required for decoding of a few frames.

Therefore, a cheaper processor can be used as a CPU 1.

A digital signal processing apparatus for encoding by the software process will now be described. Fig. 7 is a block diagram showing an internal construction of the digital signal processing apparatus to which the invention is applied. A CPU (Central Processing Unit) 11 executes predetermined processes in accordance with a program stored in a memory 12 comprising an ROM (Read Only Memory), an RAM (Random Access Memory), or the like. A video frame buffer 13 temporarily stores video data inputted via an input/output interface 14. An encoder 15 encodes the video data stored in the video frame buffer 13 and outputs it to a code buffer 16. The code buffer 16 temporarily stores the encoded video data. The video data stored in the code buffer 16 is outputted to another apparatus, for example, a recording apparatus (not shown) through the input/output interface 14. Those sections are mutually connected by a bus 17.

The video frame buffer 13 has a capacity which can store video data of a plurality of frames and a plurality of buffers have been defined as shown in Fig. 8. That is, N buffers 13-1 to 13-N have been defined in the video frame buffer 13. Video data 1 is stored in the buffer 13-1, the video data 2 is stored in the buffer 13-2, and the video data N is stored in the buffer 13-N, respectively. The buffers 13-1 to 13-

predicted in step S41 is read out from the video frame
buffer 13 and encoded by the encoder 15. The video
data encoded by the encoder 15 is stored in the code
buffer 16. When the video data is stored in the code
buffer 16, the video data encoded in step S43 is
deleted from the video frame buffer 13 in step S44. At
the same time, the ID of the buffer in the video frame
buffer 13 in which the encoded video data has been
stored is abandoned (outputted) from the FIFO.

The encoding by the encoder 15 is executed
when the CPU 11 does not perform another process, when
the video data has been stored in the video frame
buffer 13, and when the empty capacity enough to store
the encoded video data remains in the code buffer 16 as
mentioned above.

A series of processes of the encoding
apparatus 10 as mentioned above will be further
explained with reference to Figs. 11 and 12. When
video data (a) is inputted to the encoding apparatus 10
at time t, the processes described with reference to
the flowchart of Fig. 9 are executed. The inputted
video data (a) is stored in the allocated buffer in the
video frame buffer 13. When video data (b) is inputted
at time t+1, the inputted video data (b) is stored in
the allocated buffer in the video frame buffer 13 by a
process similar to that in the case where the video
data (a) is inputted. At time t+1, the process in step

S41 in the flowchart of Fig. 4B is executed, namely,
the encoding amount at the time of encoding the video
data (a) is predicted with respect to the video data
(a) stored in the video frame buffer 13. A time
5 interval between time t and time $t+1$ is set to, for
example, 33.36 msec in case of the NTSC system. The
other time intervals are also the same as it.

When it is determined by the process in step
S42 that the data of the encoding amount at the time
10 when the video data (a) has been encoded can be stored
in the code buffer 16, the encoding by the encoder 15
is started. In this case, since nothing is stored in
the code buffer 16, it is determined that there is the
empty capacity enough to store the encoded video data
(a). When video data (c) is inputted and stored in the
15 video frame buffer 13 at time $t+2$, the CPU 1 allows the
encoder 5 to encode the video data (a). As a process
in step S43, when the video data (a) is read out from
the video frame buffer 13, encoded by the encoder 15,
and stored in the code buffer 16, as a process in step
20 S44, the video data (a) (ID corresponding to the buffer
in which the video data (a) has been stored) stored in
the video frame buffer 13 is deleted.

At time $t+2$, there is still a time until next
25 time $t+3$ at a time point when the storage of the video
data (c) and the encoding of the video data (a) are
finished and an empty capacity enough to store the

encoded video data (b) remains in the code buffer 16.
Therefore, not only the encoding of the video data (a)
but also the encoding of the video data (b) are
started. However, when input time $t+3$ of video data
5 (d) comes and the video data (d) is inputted during the
encoding of the video data (b), the encoding of the
video data (b) is interrupted while the video data (d)
is being inputted (stored). When the input of the
video data (d) is finished, the encoding of the video
10 data (b) is restarted. The encoding of the video data
(b) is finished and the encoding of the video data (c)
is also completed until time $t+4$. Therefore, just
before time $t+4$, a state where only the video data (d)
newly inputted has been stored in the video frame
15 buffer 13 is obtained, and a state where the video data
(a), video data (b), and video data (c) which had
already been encoded have been stored in the code
buffer 16 is obtained.

As mentioned above, when the video data
20 stored in the video frame buffer 13 is encoded, its
encoding amount differs every video data. Therefore,
even in the case where the time which is required for
encoding also differs, there is no need to finish the
process within a predetermined processing time (in the
25 input period in which the video data is inputted), so
that the encoding precision can be raised.

Video data (e) is inputted and stored in the

video frame buffer 13 at time $t+4$. At this time point, since the video data (d) has already been stored in the video frame buffer 13 and the CPU 1 does not perform another process, it can execute the encoding process.

5 However, since the empty capacity in the code buffer 16 is not enough, the encoding is not performed. Video data (f) is inputted at time $t+5$ (Fig. 12) and a predetermined amount of video data stored in the code buffer 16 is continuously outputted to another
10 apparatus, for example, a recording apparatus or the like. In this output process, since it is sufficient that the CPU 11 instructs only the start of the reading process by providing a DMAC (Direct Memory Access Controller) or the like and allowing the data to be DMA
15 transferred, the video data can be outputted without tasking the CPU 1 itself.

Since the video data stored in the code buffer 16 is outputted, an empty capacity is produced in the code buffer 16 itself. Therefore, the encoding
20 is restarted at time $t+6$. After that, as described with reference to the flowcharts of Figs. 9 and 10, the storing process to the video frame buffer 13 and the encoding process are similarly executed.

As mentioned above, the encoding process for
25 one video data is executed in consideration of the empty capacity in the code buffer 6 and the empty time of the CPU 11, thereby enabling the encoding process to

be performed without being restricted by a condition such that the process has to be finished within the input period of the video data. Thus, even if the processor (CPU 11) of the low processing ability is used in the encoding apparatus 10, the encoding can be performed at high precision and both of the input and the encoding of the video data can be performed.

A medium which is used for installing a program for executing the foregoing series of encoding or decoding processes into a computer and setting the program into a state where it can be executed by the computer will now be described with reference to Fig. 13.

As shown in Fig. 13A, the program can be provided for the user in a state where it has previously been installed in a hard disk 22 or a semiconductor memory 23 (corresponding to the memory 2) as a recording medium built in a personal computer 21.

Otherwise, as shown in Fig. 13B, the program can be temporarily or permanently stored in a recording medium such as floppy disk 31, CD-ROM 32, MO disk 33, DVD 34, magnetic disk 35, semiconductor memory 36, or the like and provided as package software.

Further, as shown in Fig. 13C, the program can be transferred from a downloading site 41 to a personal computer 43 through a satellite 42 in a wireless manner, or can be transferred to the personal

computer 43 in a wired or wireless manner through a network 51 such as local area network or Internet and can downloaded to a built-in hard disk or the like in the personal computer 43.

5 The "medium" in the specification denotes a broad concept including all of those media.

Although the access unit has been set to the frame in the above description, it can be also set to a field. Although the case of decoding the digital
10 signal encoded by the MPEG system has been shown as an example, the encoding (compression) and its decoding (decompression) process can be also obviously performed by other systems.

As mentioned above, according to the digital
15 signal processing apparatus according to claim 1, the digital signal processing method according to claim 3, and the providing medium according to claim 4, the stored outputting order of the digital signal of the access units is managed by the FIFO format. Therefore,
20 the decoding process can be performed by an inexpensive apparatus while keeping the real-time performance by the software.

According to the digital signal processing
25 apparatus according to claim 5, the digital signal processing method according to claim 6, and the medium according to claim 7, the data amount at the time when the inputted video data is encoded is predicted, the

video data is encoded, the encoded video data is stored, the encoding is performed when it is determined that the data of the predicted amount can be stored, and the encoding is interrupted while the video data is being inputted and processed. Therefore, the encoding can be performed at high precision even in case of using the processor of the low processing ability.

The invention is not limited to the foregoing embodiments or the like but many modifications and variations are possible within the scope of claims without departing from the spirit of the present invention.

CLAIMS

1. A digital signal processing apparatus comprising:

input means for inputting an encoded digital signal;

decoding means constructed by software for decoding said digital signal inputted by said input means;

first storing means for storing the digital signal decoded by said decoding means by an amount corresponding to a plurality of access units; and

managing means for managing an outputting order of said digital signal of the access units stored in said first storing means by an FIFO format.

2. A digital signal processing apparatus according to claim 1, wherein said decoding means decodes said digital signal by an MPEG system.

3. A digital signal processing method comprising:

an input step of inputting an encoded digital signal;

a decoding step of decoding said digital signal inputted by a process in said input step by software;

a first storing step of storing the digital signal decoded by a process in said decoding step by an amount corresponding to a plurality of access units;

and

5 a managing step of managing an outputting
order of said digital signal of the access units stored
by a process in said first storing step by an FIFO
format.

4. A providing medium for providing a computer-
readable program for allowing a digital signal
processing apparatus to execute processes, wherein said
processes comprise:

10 an input step of inputting an encoded digital
signal;

a decoding step of decoding said digital
signal inputted by a process in said input step by
software;

15 a first storing step of storing the digital
signal decoded by a process in said decoding step by an
amount corresponding to a plurality of access units;
and

20 a managing step of managing an outputting
order of said digital signal of the access units stored
by a process in said first storing step by an FIFO
format.

5. A digital signal processing apparatus
comprising:

25 input means for inputting video data;

first storing means for storing said video
data inputted by said input means;

predicting means for predicting a data amount
at the time when said video data stored in said first
storing means is encoded;

encoding means for encoding said video data
stored by said first storing means; and

second storing means for storing the video
data encoded by said encoding means,

wherein the encoding by said encoding means
is executed if it is determined that the data of said
amount predicted by said predicting means can be stored
in said second storing means, and the encoding is
interrupted while said video data is being inputted by
said input means and is being processed.

6. A digital signal processing method
comprising:

an input step of inputting video data;

a first storing step of storing said video
data inputted by said input step;

a predicting step of predicting a data amount
at the time when said video data stored in said first
storing step is encoded;

an encoding step of encoding said video data
stored by said first storing step; and

a second storing step of storing the video
data encoded by said encoding step,

wherein the encoding in said encoding step is
executed if it is determined that the data of said

amount predicted by said predicting step can be stored by a process in said second storing step, and the encoding is interrupted while said video data is being inputted by said input step and being processed.

5 7. A medium for allowing a computer to execute a program, wherein said program comprises:

an input step of inputting video data;

a first storing step of storing said video data inputted by said input step;

10 a predicting step of predicting a data amount at the time when said video data stored in said first storing step is encoded;

an encoding step of encoding said video data stored by said first storing step; and

15 a second storing step of storing the video data encoded by said encoding step, and

the encoding in said encoding step is executed if it is determined that the data of said amount predicted by said predicting step can be stored by a process in said second storing step, and the encoding is interrupted while said video data is being inputted by said input step and being processed.

20

ABSTRACT

In case of decoding by a software process, in the process 1, video data of a decoded frame corresponding to a management ID stored at the head of an output FIFO 4 at its time point is read out and outputted. In the process 2, audio data is decoded. In the process 3, the video data is decoded. The decoded video data is stored in a video frame buffer and its management ID is stored in the output FIFO 4 in the outputting order. When the process 3 cannot be finished, the process 3 is interrupted during the process and the image of the frame stored at the head of the output FIFO 4 is outputted. After that, when the process 2 is finished, the decoding process of the process 3 which was temporarily interrupted is restarted. In case of performing the encoding by the software process, an encoding amount of the video data as a processing target of the encoding is predicted. Subsequently, whether an empty capacity enough to store the data of the predicted encoding amount exists in a code buffer or not is discriminated. If it is determined that there is the empty capacity, the encoding is started and the video data in which the encoding was finished is deleted from the video frame buffer. The encoding is temporarily interrupted when a reading process or the like of the video data is performed.

The diagram illustrates a system architecture where a central CPU (1) is connected to a 7 BUS. This bus is further connected to five peripheral components: PROGRAM MEMORY (2), VIDEO FRAME BUFFER (3), OUTPUT FIFO (4), STREAM INPUT I/F (5), and DISPLAY CONTROLLER (6). Bidirectional arrows indicate data flow between the CPU and the bus, and between the bus and each peripheral component.

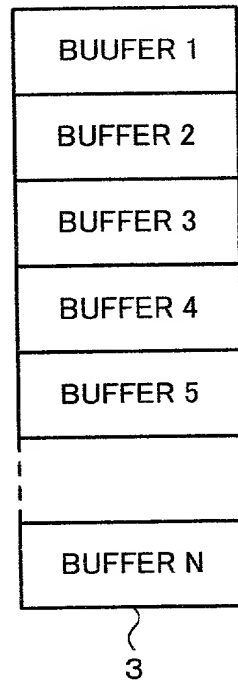
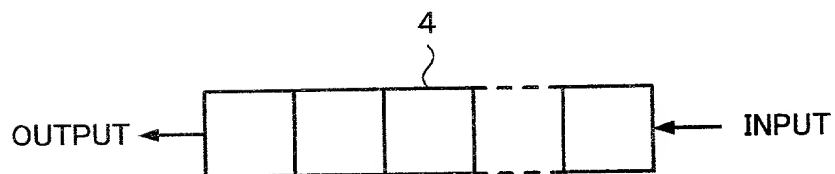
Fig. 2**Fig. 3**

Fig. 4

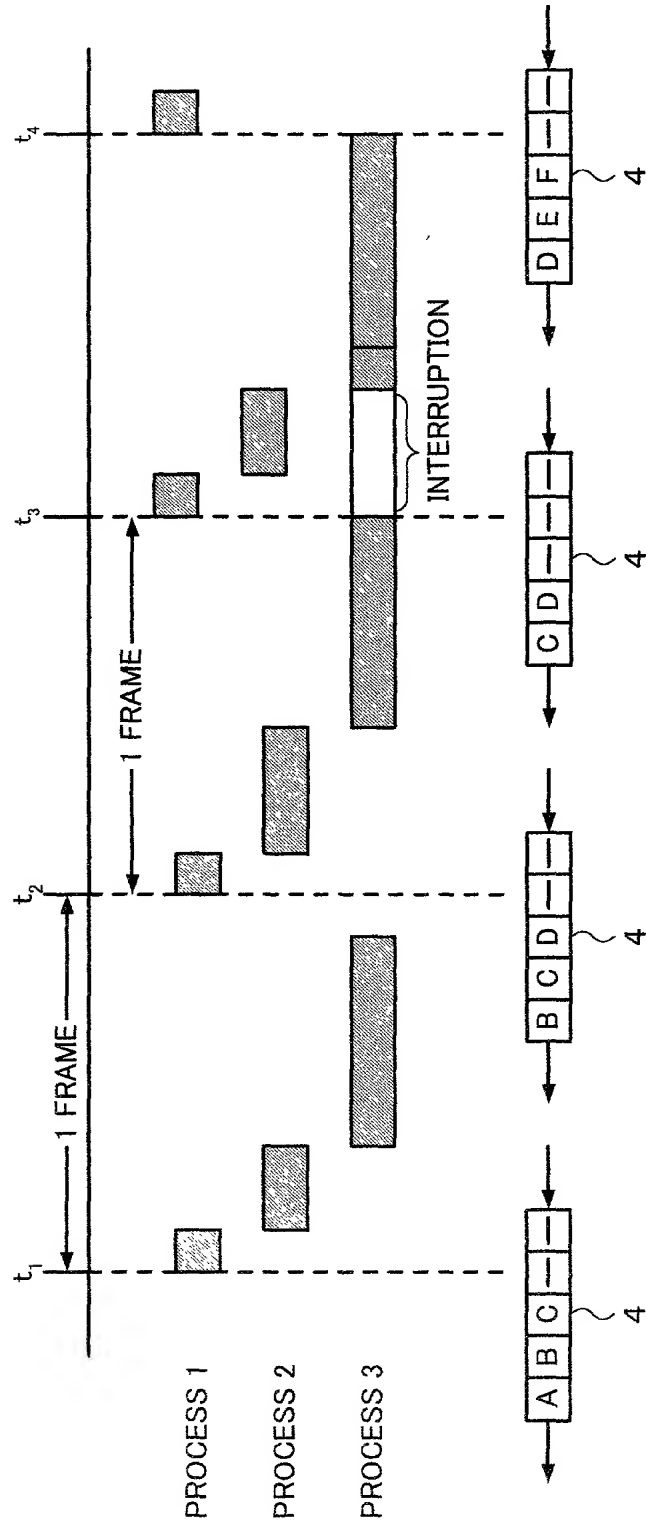


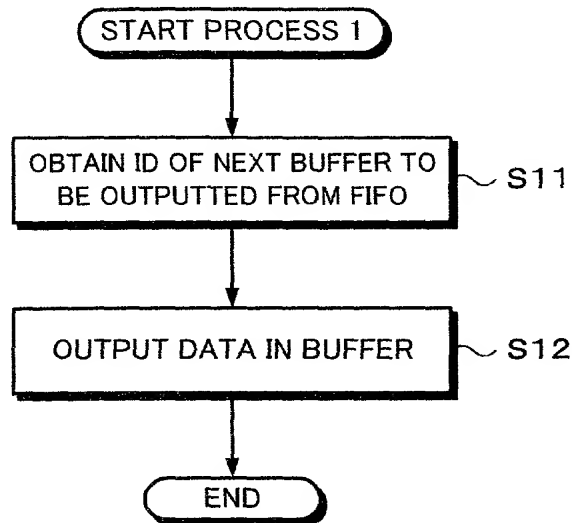
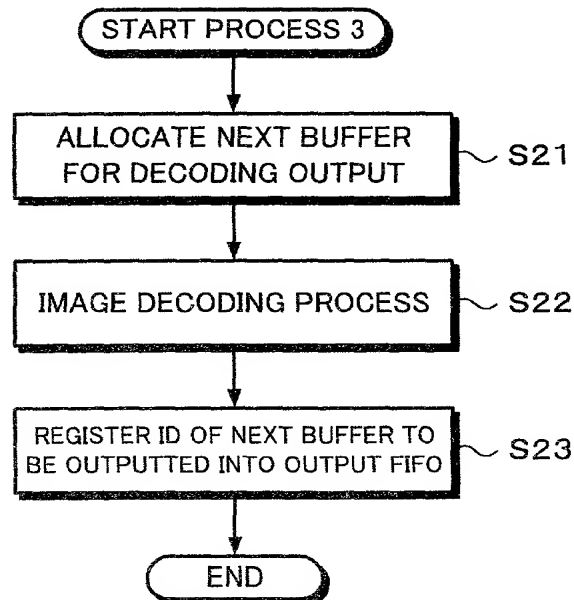
Fig. 5**Fig. 6**

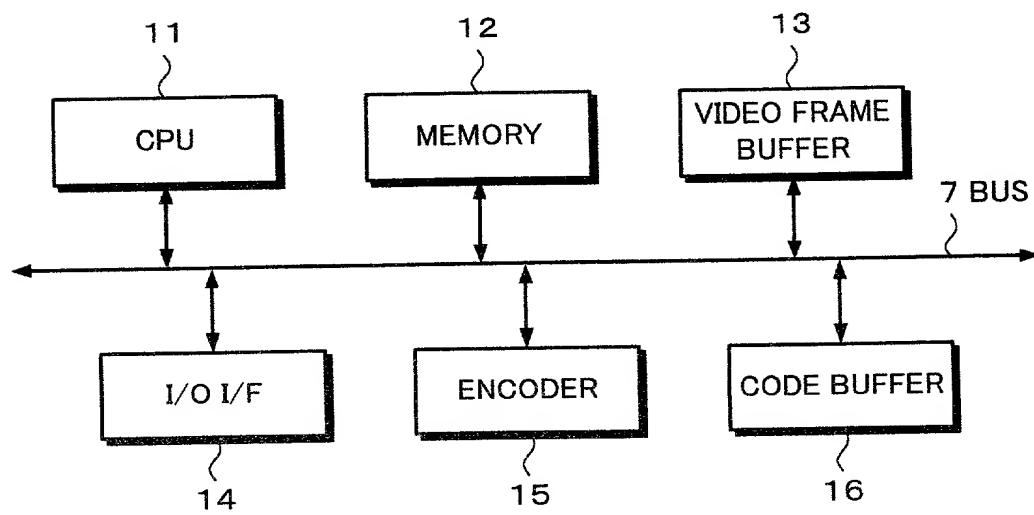
Fig. 7ENCODING APPARATUS 10

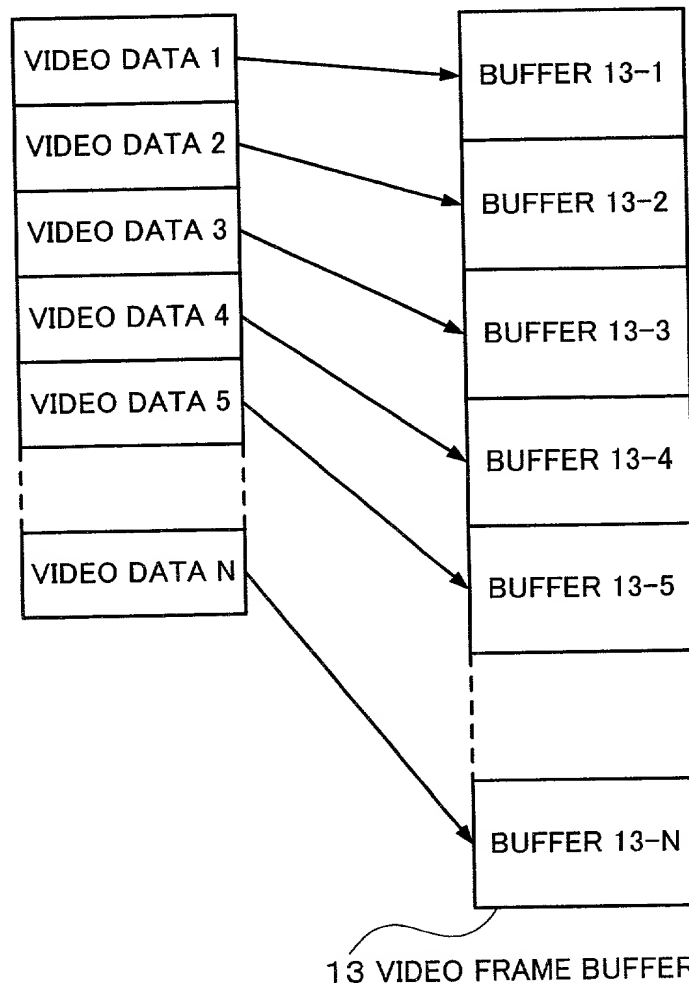
Fig. 8

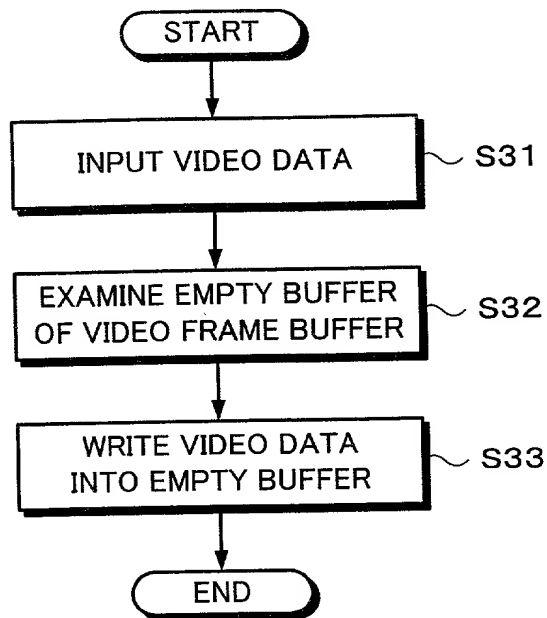
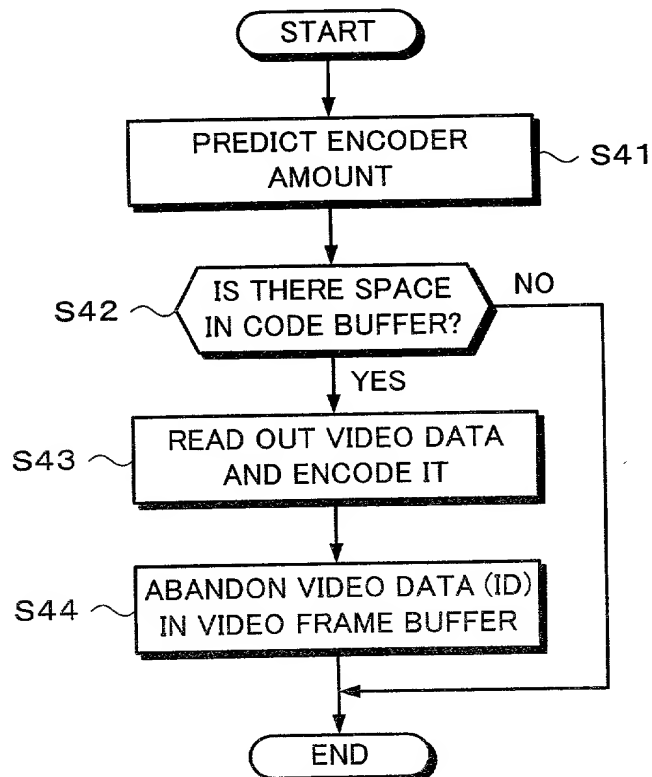
Fig. 9**Fig. 10**

Fig. 11

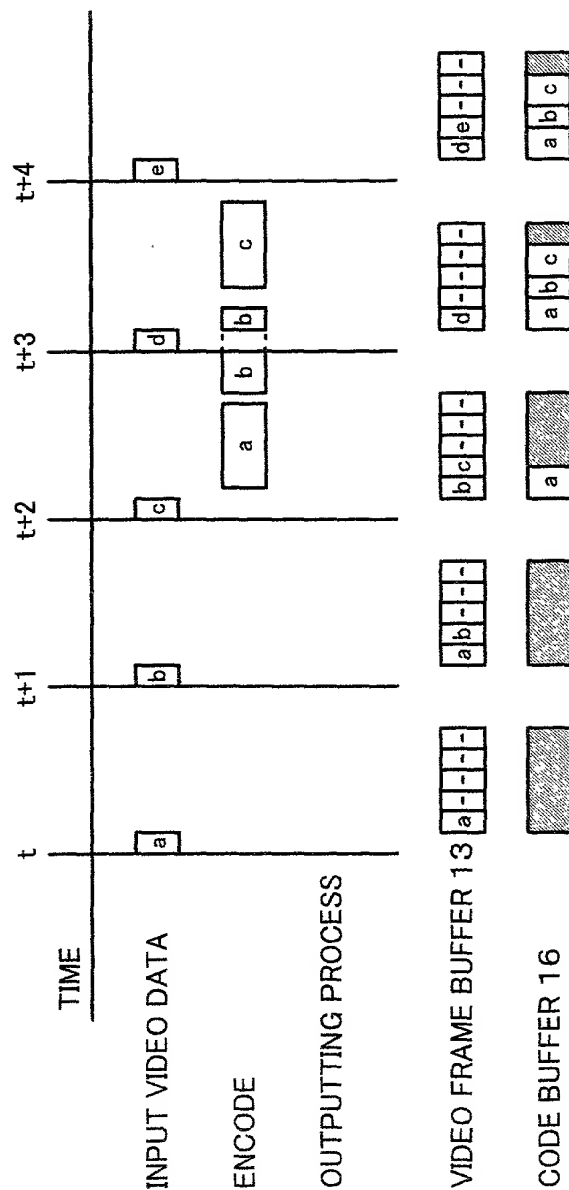


Fig. 12

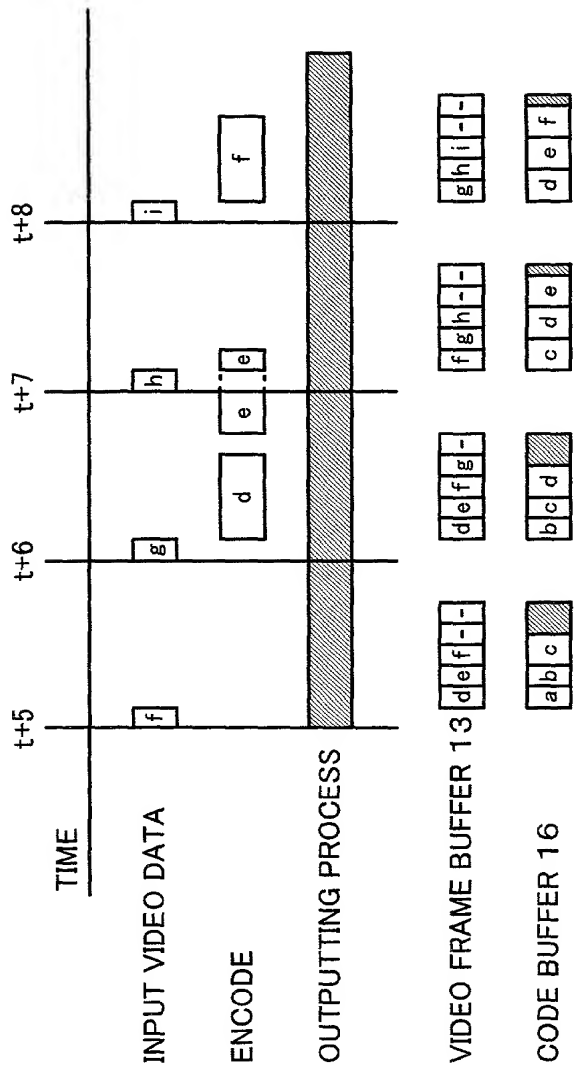
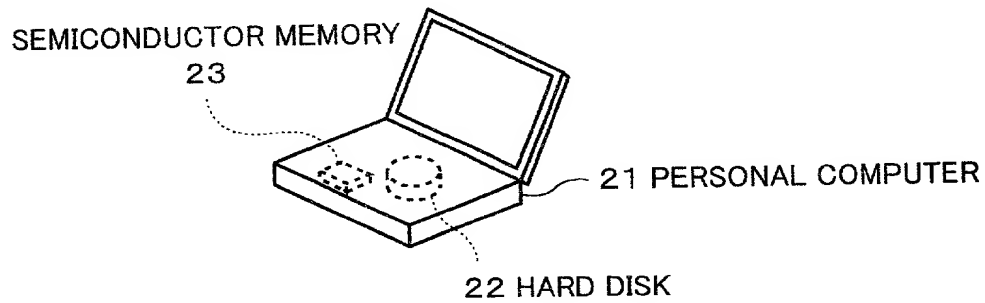
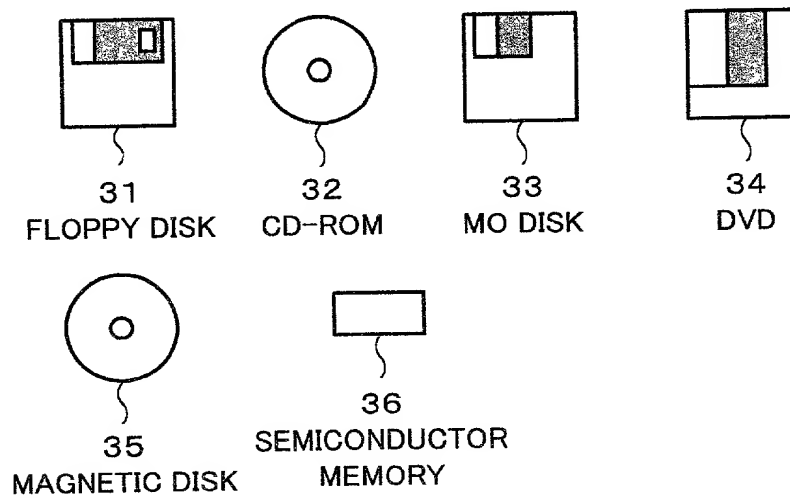
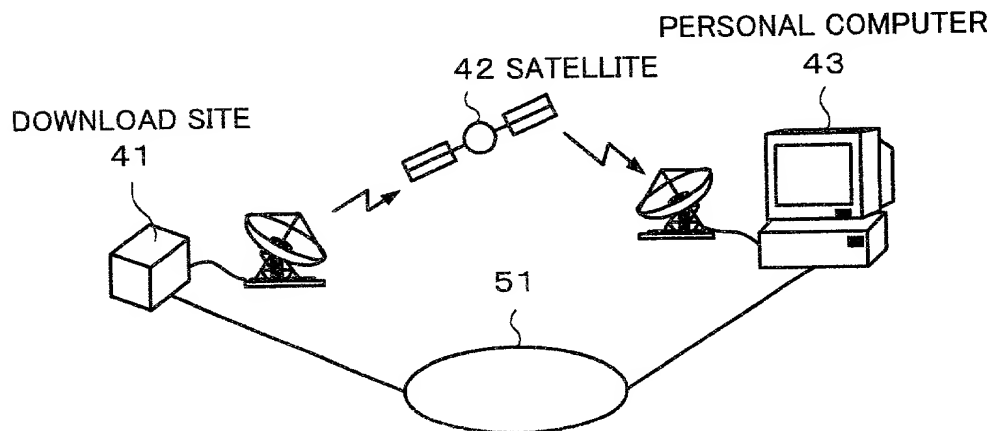


Fig. 13A**Fig. 13B****Fig. 13C**

- 1 CPU
- 2 PROGRAM MEMORY
- 3 VIDEO FRAME BUFFER
- 4 OUTPUT FIFO

09/674887

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As a below named inventor, I hereby declare that:

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My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Digital Signal Processing Apparatus

and Method and Providing Medium

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☒ was filed on March 8, 2000
as United States Application Number or
PCT International Application Number
PCT/JP00/01384 and was amended on _____
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Prior Foreign Application(s)

外国での先行出願
060316/1999

(Number)
(番号)
172013/1999
(Number)
(番号)

Japan
(Country)
(国名)
Japan
(Country)
(国名)

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed

優先権主張なし

08 March 1999

(Day/Month/Year Filed)
(出願年月日)

18 June 1999

(Day/Month/Year Filed)
(出願年月日)

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(Application No.)
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(Filing Date)
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(Filing Date)
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(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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(Supply similar information and signature for third and subsequent joint inventors.)

Declaration and Power of Attorney For Patent Application -- Additional Prior Foreign Applications

<u>Number</u>	<u>Country</u>	<u>(Day/Month/Year Filed)</u>	<u>Priority Not Claimed</u>
	<u>Japan</u>		<input type="checkbox"/>
	<u>Japan</u>		<input type="checkbox"/>

Declaration and Power of Attorney For Patent Application -- Additional Inventors

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Third Inventor's signature Masahito YAMANE Date November 22, 2003

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Fourth Inventor's signature _____ Date _____

Residence:

Citizenship:

Post Office Address:

Full name of fifth joint inventor, if any (given name, family name):

Fifth Inventor's signature _____ Date _____

Residence:

Citizenship:

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